Hearing Aid Usage in Different Listening Environments

Sarah Eddie, BA and Emily Lin, PhD
Department of Communication Disorders, University of Canterbury, Christchurch, New Zealand

Abstract

This study investigates the daily listening environments of hearing aid users through their hearing aid data logging capacity. Based on a preliminary investigation of data logging information from 72 hearing aid adult users, including 64 males and 8 females, it was found that the majority of the hearing aid user's time in their main listening program was spent, on average, in "Speech in Quiet" situation (44.34%), followed in order by "Quiet Only" (29.33%), "Noise only" (15.16%), and "Speech in Noise" (11.06%) situations. This finding provides information regarding the general listening pattern of hearing aid users and thus serves as the basis for clinicians to identify unusual individual patterns for better follow-up services.

Introduction

•People participate daily in a variety of listening situations. Since data logging is now available in a number of hearing aid models, information about a hearing aid user's listening situations while wearing their hearing aid has become obtainable. This feature aims to help Audiologists in troubleshooting problems or making fine-tuning decisions. The logging of time spent in different listening situations is a useful feature of data logging because it allows for examination of the general pattern of the user's daily listening environments. Recently, the idea that a hearing aid user's listening environments are very important in prescribing desired hearing aid features has been discussed (Gatehouse, Elberling, & Naylor, 1999; Gatehouse, Naylor, & Elberling, 2003, 2006; Jensen & Nielsen, 2005; Kates, 1995). For example, Jensen and Nielsen (2005) asked participants to make short sound recordings of their daily listening situations on small portable recorders and found that "auditory ecology", which refers to the auditory environments people are faced with and the subjective importance of these environments (Gatehouse et al., 1999), is important for the prescribing and fitting of hearing aids. The time spent in these daily listening situations can be recorded objectively by the data logging feature of hearing aids.

The variation in time spent in different listening environments has had little coverage in the literature (Jensen & Nielsen, 2005). These researchers found a large variation in the individual distributions of different sound environments with no clear pattern between auditory ecology and personal characteristics and suggested that this great variability might be due to the method used where participants were given the control over choosing situations to record. Using the data logging feature of hearing aids as a tool to examine listening environments may improve the measurement reliability. Therefore, we employed data logging to address the question: What is the general behaviour of the hearing aid user in regards to time spent in different listening environments?

Background

As shown in Tables 1 and 2 by the data logging information for two hearing aids, the Oticon Syncro (Syncro) and the GN ReSound Metrix (Metrix), the data logging feature records a number of different hearing aid behaviours. The Metrix is a 17-channel, dual-microphone instrument, and the Syncro is an 8-channel, dual-microphone instrument. The Syncro uses the Syncro Memory™ feature in the Oticon Genie 7.0 software to display the data logging information. Examples of these instruments are shown in figures 1 to 4. The Metrix uses the Onboard Analyzer™ feature in the GNReSound Aventa 2.0 software. Screenshots of these softwares are shown in figures 5 to 7.

Table 1. Data Logging Information for Oticon Syncro

Data Logged	Situations	Units
Average Total Usage		Hours per day
Relative Program Usage		%
Average Use per Program		Hours per day
Average Volume Control (VC) Setting	Soft Moderate Loud	dB deviation from prescribed setting
Overall VC usage	Soft Moderate Loud	% of time VC up/down
Relative Microphone Mode Usage	Surround Split Directional Full Directional	%
Relative Listening Environment Usage	Quiet Speech Only Speech in Noise Noise Only	%
"Envirograms" - Relative Overall Sound Level Usage	<40 dB 40-50 dB 50-60 dB 60-70 dB 70-80 dB >80 dB	%

Table 2. Data Logging Information for Resound Metrix

Data Logged	Situations	Units
Total Usage Time		Hours
Usage Time per Program	Each Program	Hours
Total Number of Instrument Usn		Frequency
Hours per Use	0–4 hours 4–8 hours 8–12 hours 12–16 hours 16–20 hours 20+ hours	Frequency
Number of Program Changes		Frequency
Average Sound Level	Each Program	dB SPL
Listening Environment Usage	Quiet Speech (soft) Speech (Loud) Speech in Noise (Moderate) Speech in Noise (Loud) Noise (Moderate) Noise (Loud)	Hours
Mean and SD VC Change	Each Program	dB
Number of VC adjustments (Increase and Decrease)	Quiet Speech (soft) Speech (Loud) Speech in Noise (Moderate) Speech in Noise (Loud) Noise (Moderate) Noise (Loud)	Frequency
Mean and SD VC change over time	5 hours 15 30 60 120 240 320	dB
Mean and SD VC change	Quiet Speech (soft) Speech (Loud) Speech in Noise (Moderate) Speech in Noise (Loud) Noise (Moderate) Noise (Loud)	dB

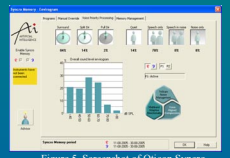

Figure 5. Screenshot of Oticon Syncro Datalogging Software2

Figure 1. Oticon Syncro BTE (Oticon Syncro Product Information: www.oticon.co.nz)

Figure 2. ReSound Metrix BTE (ReSound Metrix Product Information: www.gnresound.co.nz)

Figure 3. Oticon Syncro ITEs (Oticon Syncro Product Information: www.oticon.co.nz)

Figure 4. ReSound Metrix ITE (ReSound Metrix Product Information: www.gnresound.co.nz)

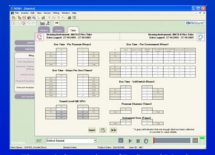

Figure 6. Screenshot of ReSound Metrix Datalogging Software

Method

Participants

Seventy-two hearing aid wearers were recruited from two private Audiology clinics in Christchurch, New Zealand. Each participant had been fitted with either Syncro or Metrix hearing aids between June 2005 and the 1st of August 2006. The participants' details are outlined in Table 3.

Table 3. Participants

Sex	Male = 64	Female = 8
Mean Age	68.9 years (SD = 11.43)	
Mean 3 Frequency Average	41 dB HL (SD = 14.62)	
Mean HFA	53 dB HL (SD = 13.79)	
Hearing Aid	Oticon Syncro = 36	ReSound Metrix = 36
Binaural vs Monaural	Binaural = 69	Monaural = 3
Hearing Aid Style	BTE = 31 ITC = 20 ITE = 19 CIC = 1 BTE & ITE = 1	

Procedure

All participants were given routine clinical instructions on hearing aid use at the fitting appointment. No task was required of the participants except to carry out their normal daily activities between the fitting and follow-up appointments. This was ensured as the participants were unaware of their involvement in the study until data was collected. The data logging information was obtained as part of the first routine follow-up appointment which was held two to three weeks after the initial hearing aid fitting. The data was automatically uploaded onto the Audiologist's computer when the hearing aids were connected for fine-tuning, via the software outlined above. The information was later manually recorded by the researchers.

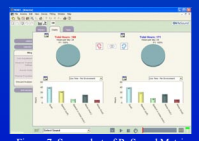

Figure 7. Screenshot of ReSound Metrix Datalogging Software

Measurement and Data Analysis

The downloaded data logging information was manually recorded by the researchers. For each participant, the total number of hours of use, the average daily use, and the percentage of time in each listening situation (Quiet, Speech in Noise, Noise Only, and Speech in Quiet) in the program with the most use was recorded for further analysis. The Oticon software displays listening environment information in four levels (see Table 1), whereas the GN ReSound software displays the same information in seven levels (see Table 2). To be reduced to the same four levels as the Oticon data for better comparison, the GN ReSound data were recategorised, with the 'speech (soft)' and 'speech (loud)' levels grouped as 'speech only', 'speech in noise (moderate)' and 'speech in noise (loud)' as 'speech in noise', and 'noise (moderate)' and 'noise (loud)' as 'noise only'.

Results

Listening Environments

While most participants (n = 61) provided data for both the left and right hearing aids, some (n = 11) only had data available for one ear. Results of a two-way Repeated Measures ANOVA performed for participants with data from both ears revealed a significant situation effect [F(3, 180) = 74.93, p < 0.001] but no significant ear effect [F(1, 60) = 0.0524, p = 0.820] and no significant interaction between ear and listening situation [F(3, 180) = 0.00725, p = 0.999] on the time usage. Since the time spent in different listening situations was not found to differ between ears, data from participants with hearing aids on both ears were averaged between data from the right and left ears and then combined with data from participants with data only from one ear to simplify data analysis. The resulting mean percentage of time spent in each listening environment for all participants is shown in Figure 8. Results of a Kruskal-Wallis one-way ANOVA on ranks showed a significant difference among the time spent in different listening situations (H = 173.683, df = 3, p < 0.001). Post-hoc multiple pair-wise comparisons using the Dunn's test showed a significant difference between all pair-wise comparisons except for the comparison between "Speech in Noise" and "Noise Only" situations. For the Syncro hearing aids, a significant difference was also found among the time spent in different listening situations (H = 86.428, df = 3, p < 0.001). Post-hoc tests showed a significant difference between all pair-wise comparisons except for the comparison between "Speech in Noise" and "Noise Only" situations (see Table 4 and Table 5).

Three one-way ANOVAs on ranks were performed separately on data from participants with BTE style hearing aids (n = 31), with ITC style hearing aids (n = 20), and with ITE style hearing aids (n = 19). For all of these hearing aid styles, the Kruskal-Wallis one-way ANOVA test results revealed a significant difference between the time spent in different listening situations. The results of post-hoc multiple pair-wise comparisons using the Tukey test are shown in Table 5.

Age Effect

The participants were divided into four groups by age. The groups were 50-59, 60-69, 70-79, and 80-89 years. Results of four Kruskal-Wallis one-way ANOVAs on ranks performed on each group separately revealed a significant difference among the time spent in different listening situations. The results of post-hoc multiple pair-wise comparisons using the Tukey test are shown in Table 6.

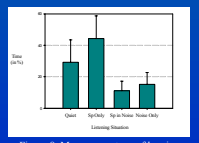

Figure 8. Mean percentage of hearing aid use time spent in four different listening environments, including Quiet, Speech (Sp) Only, Sp in Noise, and Noise Only.

Hearing Aid Manufacturer Effect

Two one-way ANOVAs on ranks were performed separately on data from participants with Metrix hearing aids (n= 36) and on data from those with Syncro hearing aids (n= 36). For the Metrix hearing aids, results of the Kruskal-Wallis one-way ANOVA on ranks revealed a significant difference among the time spent in different listening situations (H = 84.307, df = 3, p < 0.001). Post-hoc multiple pair-wise comparisons using the Dunn's test showed a significant difference between all pair-wise comparisons except for the comparison between "Speech Only" and "Quiet" and between "Speech in Noise" and "Noise Only" situations. For the Syncro hearing aids, a significant difference was also found among the time spent in different listening situations (H = 86.428, df = 3, p < 0.001). Post-hoc tests showed a significant difference between all pair-wise comparisons except for the comparison between "Speech in Noise" and "Noise Only" situations (see Table 4 and Table 5).

Hearing Aid Style Effect

Table 5. Post-hoc multiple pair-wise comparisons for Hearing Aid Style using the Tukey test. Significant differences are shown as 'Yes', indicating p<0.05. Similarities between Styles are shown in red.

	BTE	ITC	ITE
Sp Only vs. Sp in Noise	Yes	Yes	Yes
Sp Only vs. Noise Only	Yes	Yes	Yes
Sp Only vs. Quiet	No	Yes	Yes
Quiet vs. Sp in Noise	Yes	Yes	Yes
Quiet vs. Noise Only	Yes	Yes	No
Noise Only vs. Sp in Noise	No	No	No

Table 6. Post-hoc multiple pair-wise comparisons for Age (in years) using the Tukey Test. Significant differences are shown as 'Yes', indicating p<0.05. Similarities between age ranges are shown in red.

	50-59 vs. 60-69	50-59 vs. 70-79	50-59 vs. 80-89
Sp Only vs. Sp in Noise	Yes	Yes	Yes
Sp Only vs. Noise Only	Yes	Yes	Yes
Sp Only vs. Quiet	Yes	No	No
Quiet vs. Sp in Noise	No	Yes	Yes
Quiet vs. Noise Only	No	Yes	Yes
Noise Only vs. Sp in Noise	No	No	No

Microphone Modes

For the Syncro hearing aid, the datalogging screen shows the relative percentage of time spent in each of three microphone modes; surround, split directional, and full directional. To assess any difference between ears, a Pearson Product Moment Correlation procedure was performed on data from participants with Syncro hearing aids with bilateral ear information (n = 29). The correlation between ears was high (r = 0.978, p<0.01).

Enviograms

Enviograms, created by Oticon for its datalogging software, are histograms of the relative overall sound level usage in dB SPL. Results of a two-way Repeated Measures ANOVA performed on participants with data from both ears revealed a significant sound level effect [F(5, 348) = 35.0, p < 0.001] but no significant ear effect [F(1, 348) = 0.0007, p = 0.979] and no significant interaction between ear and sound level [F(5, 348) = 0.718, p = 0.610]. Left and right ear information was averaged and added to data from participants with single ear information. The resulting mean percentage of time spent in each sound level range for all participants with Syncro hearing aids (n = 36) is shown in figure 9.

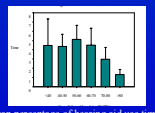

Figure 9. Mean percentage of hearing aid use time spent in six sound level ranges. Time is ranked, where ranks 1 to 8 represent consecutive 5% ranges from 0-5% to 35-40%.

Discussion

Listening Environments

The overall pattern of the hearing aid users' behaviours, in terms of time spent in different listening environments, showed that the listening environment most often experienced by the hearing aid user was "Speech in Quiet" situation, followed by "Quiet" situation and then by two situations with similar amount of time usage, "Speech in Noise" and "Noise Only". Given the relatively high mean age of the participants in this study, this pattern of time spent in different listening environments might be a reflection of a less active lifestyle in the elderly than that in younger hearing aid users. It is noteworthy, however, that the between-subject variation was large, particularly for the "Quiet" and "Speech Only" situations. In a study with a smaller sample size (18 participants), Jensen and Nielsen (2005) also found large individual variations for each of the seven listening categories they measured, and a similar amount of time spent in situations where speech is present as in this study.

The patterns of time spent in different listening environments for each of the three hearing aid styles examined was similar, indicating that an Audiologist can expect the datalogging information to be independent of the style of hearing aid used.

The patterns of time spent in different listening environments for the three age ranges 60-69, 70-79, and 80-89 were similar, indicating that listening environments for hearing aid users tend not to change over these age ranges. However, the pattern of time spent in different listening environments for the age range 50-59 differed from the three other ranges, suggesting there is a change in listening environments for the hearing aid user after this age range.

Microphone Mode

There was no significant difference between ears in the time spent in each microphone mode. This suggests an Audiologist can be confident that both hearing aids are switching to an appropriate microphone mode at the same time. Also, it may suggest that hearing aids not equipped with technology that allows communication between ears may not be at a disadvantage, as the hearing aids in the study appear to switch to the same mode on both sides despite not having that technology.

Enviograms

Given the nature of the hearing aid users' behaviour, in terms of time spent in different overall sound levels, showed that the majority of time is spent in an overall sound level between 40 and 70 dB SPL. This information may be useful to an Audiologist as a starting-off point for trouble-shooting problems. Further examination of the Enviograms data will be carried out as part of this study.

Limitations

The major limitation of this study in terms of generalisation is that only two brands of hearing aids were included. However, data from the two different brands of hearing aids used were found to yield similar results, with both aids showing similar listening patterns as well as a significant time usage difference between listening situations. This finding suggests that the general listening pattern identified in this study is independent of the manufacturer of the hearing aid and data logging device.

This preliminary data provides a follow-up study that will examine the listening environments of hearing aid users with an Oticon data logging device called a Sound Activity Meter (SAM). The SAM is clipped to the lapel of a client, and therefore records their listening environments throughout the entire day, rather than just when they are wearing their hearing aids. The datalogging information from the SAM will be compared to that from the hearing aids, to examine whether the SAM is an accurate predictor of the listening environments the users will experience when they are actually wearing their hearing aids.

Acknowledgements

Lloyd Mander, Hearing Advantage, Christchurch, New Zealand
The Oticon Foundation in New Zealand
Letitia Wylie, Bay Audiology, Christchurch, New Zealand

the oticon foundation